Greater Cambridge Partnership

CAMBOURNE TO CAMBRIDGE

Technical Report 3 – Climate Resilience

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Greater Cambridge Partnership

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1 INTRODUCTION AND SUMMARY

1.1.1. The Cambourne to Cambridge (C2C) Scheme will include a 13.6km long mainly dedicated busway connecting Cambourne in the west with Cambridge in the east. A service road and maintenance track, to be used as an active travel path, will run alongside the segregated sections of busway. The C2C Scheme will use hybrid vehicles (and in due course, electric vehicles), providing a service of around 10 buses per hour each way. The Scotland Farm travel hub (a park and ride facility) will be situated along the route, just north of the A428, approximately 5km west of Cambridge. Further details about the Scheme proposal are set out in Chapter 3 of the ES[1].

1.1.2. This section reports the potential impacts of change in climate variables on the C2C Scheme by providing an assessment of its resilience to climate change ('Climate Resilience').

1.1.3. The requirement to consider a project's vulnerability to climate change results from the 2014 amendment to the *EIA Directive (2014/52)*[i]. The Directive has been fully transposed into UK law in the Town and Country Planning (Environmental Impact Assessment) Regulations 2017 ('EIA Regulations'). The Directive requires: "*A description of the likely significant effects of the project on the environment resulting from the impact of the project on climate (for example the nature and magnitude of greenhouse gas emissions) and the vulnerability of the project to climate change*." This Technical Report assesses the vulnerability of the project to climate change.

1.1.4. The Technical Report gives a description of the methodology and the baseline conditions relevant to the assessment, which have been used to reach a set of conclusions. It also provides a summary of the likely significant effects. It outlines the embedded and, where required, mitigation options needed to avoid, prevent or reduce any likely significant adverse effects.

1.1.5. The scope of this Technical Report has been established through the scoping process. It considers predicted impacts from temperature, precipitation and wind impacts on the C2C Scheme that may arise as a result of climate change, particularly where these may have wider implications for people (Scheme users and wider receptors) and the environment. C2C assets include the built elements (busway and service road (to be used as a shared use path), embankments, structures, drainage features, travel hub, and electrical infrastructure), as well as planting included for landscaping and ecology.

1.1.6. Due to the short and relatively immediate construction period (2025 until 2026), the resilience of the C2C Scheme to climate change during the construction stage has been scoped out of the assessment. The Code of Construction Practice[2] ('CoCP') considers extreme weather events and outlines measures to be implemented by the Principal Contractor.

[1] Environmental Statement (Document reference: C2C-10-00-Environmental Statement (Volume 1))
[2] Code of Construction Practice (Document reference: C2C-26-00-Code of Construction Practice)

1.1.7. The operational impacts of climate change that are considered are informed by the lifespan of key elements within the C2C Scheme design and the UK Climate Projections 2018 ('UKCP18'). The design life of the C2C Scheme is anticipated to be 60 years with the bridges having a lifespan of 100 years, as such, the future baseline has been presented for the 2030s, 2050s and 2080s.

1.1.8. In-combination Climate Impacts ('ICCI') assess the potential for climate change to exacerbate or ameliorate the potential effects identified within each of the environmental topics. The findings of the ICCI assessment is presented within this Technical Report.

1.1.9. The assessment of Climate Resilience has established that implemented and embedded mitigation within the C2C Scheme's CoCP, design, and monitoring and maintenance planning is sufficient to mitigate potential significant effects that may otherwise occur as a result of a changing climate.

1.1.10. This Technical Report should be read as part of the wider ES[1].

2 BASELINE ENVIRONMENT

2.1.1. The C2C Scheme is located in the Met Office climate region of East England **(Ref. 3.1)**. This is characterised by land below 60m altitude, with the Fens having the largest tract of low, flat land in the UK. Generally, the east of England is drier, warmer, sunnier and less windy than the west and north of England.

2.1.2. The Cambridge Niab weather station **(Ref. 3.2)** (approximately 5km north of central Cambridge) has been chosen as representative of the local climate. Though the C2C Scheme lies in the East England region, the Met Office UK climate average data categorises Cambridgeshire in the South of England Region. Therefore, to understand the local climate in the context of the regional and national climate, results for climate variables (temperature, precipitation and wind) are shown in combination with the South of England Region (England S) and the UK average.

2.1.3. The current and historic baseline uses data from the climate period 1981-2020 as this aligns to the baseline period used in climate projection modelling.

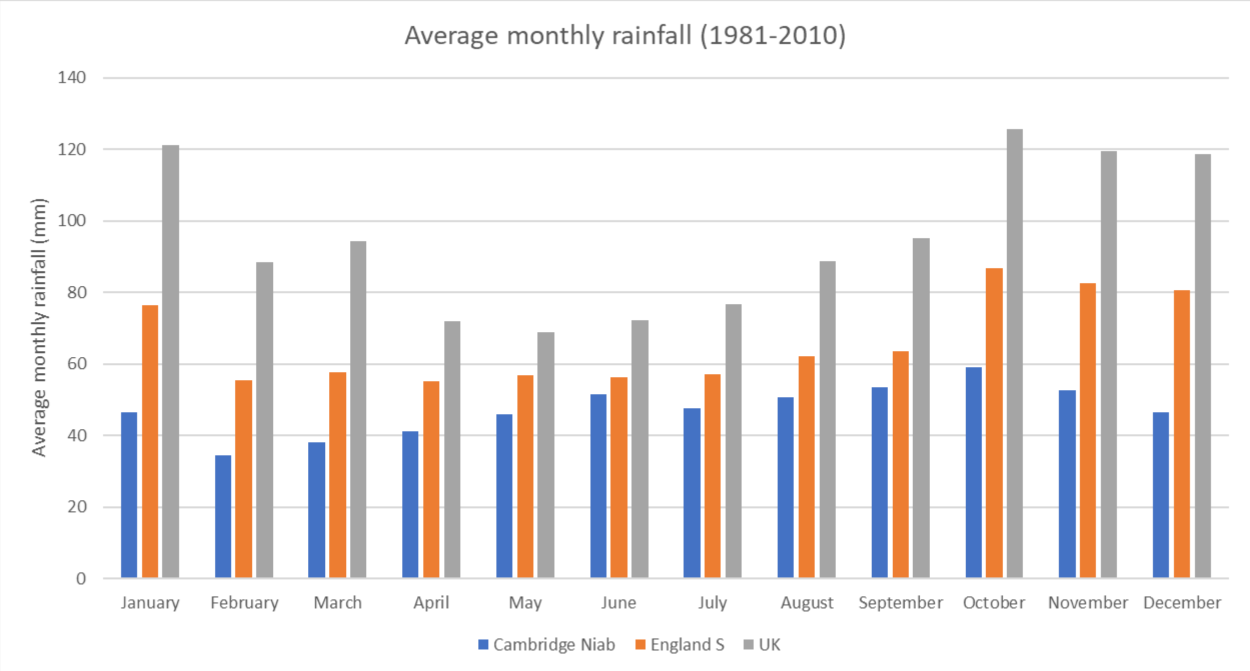
2.2 CURRENT AND HISTORIC BASELINE

PRECIPITATION

2.2.1. East England includes some of the driest areas in the country and receives less than 700mm rainfall per year. In comparison, the wettest place in England, the Lake District, receives on average over 3,000 mm rain a year. Rainfall tends to be associated with Atlantic depressions or with convection which are more vigorous in autumn and winter. In summer, convection caused by solar surface heating sometimes forms shower clouds and a large proportion of rain falls from showers and thunderstorms at this time of year. East England has a more even distribution of rainfall throughout the year than other parts of the UK, due to a 'rain-shadow' effect from winter depressions from high ground to the west, and from a higher frequency of convective rainfall in summer **(Ref. 3.1)**.

2.2.2. **Plate TR3-2-1** shows that the monthly average rainfall at Cambridge Niab weather station is lower than the regional and UK average.

Plate TR3-2-1 - Long term average monthly rainfall for the Cambridge Niab weather station, Southern England region and the UK (Ref. 3.2)



EXTREME PRECIPITATION

2.2.3. Periods of prolonged rainfall are often associated with Atlantic depressions or with convection **(Ref. 3.3)**. The Atlantic lows are more vigorous in autumn and winter. In summer, convection caused by solar surface heating sometimes forms shower clouds and a large proportion of rain falls from showers and thunderstorms at this time of year. Rainfall caused this way is normally more intense than winter rainfall which tends to be more frontal with falls occurring over longer periods.

2.2.4. **Table TR3-2-1** shows the average total number of days where rainfall exceeds 1mm in summer (June, July, and August) and winter (December, January, and February) for Cambridge Niab weather station and the UK. The data indicates that regionally, Cambridge experience less days in comparison to the UK.

Table TR3-2-1 - Long-term average of total number of days where rainfall exceeded 1mm for the baseline period (1981-2010) (Ref. 3.2)

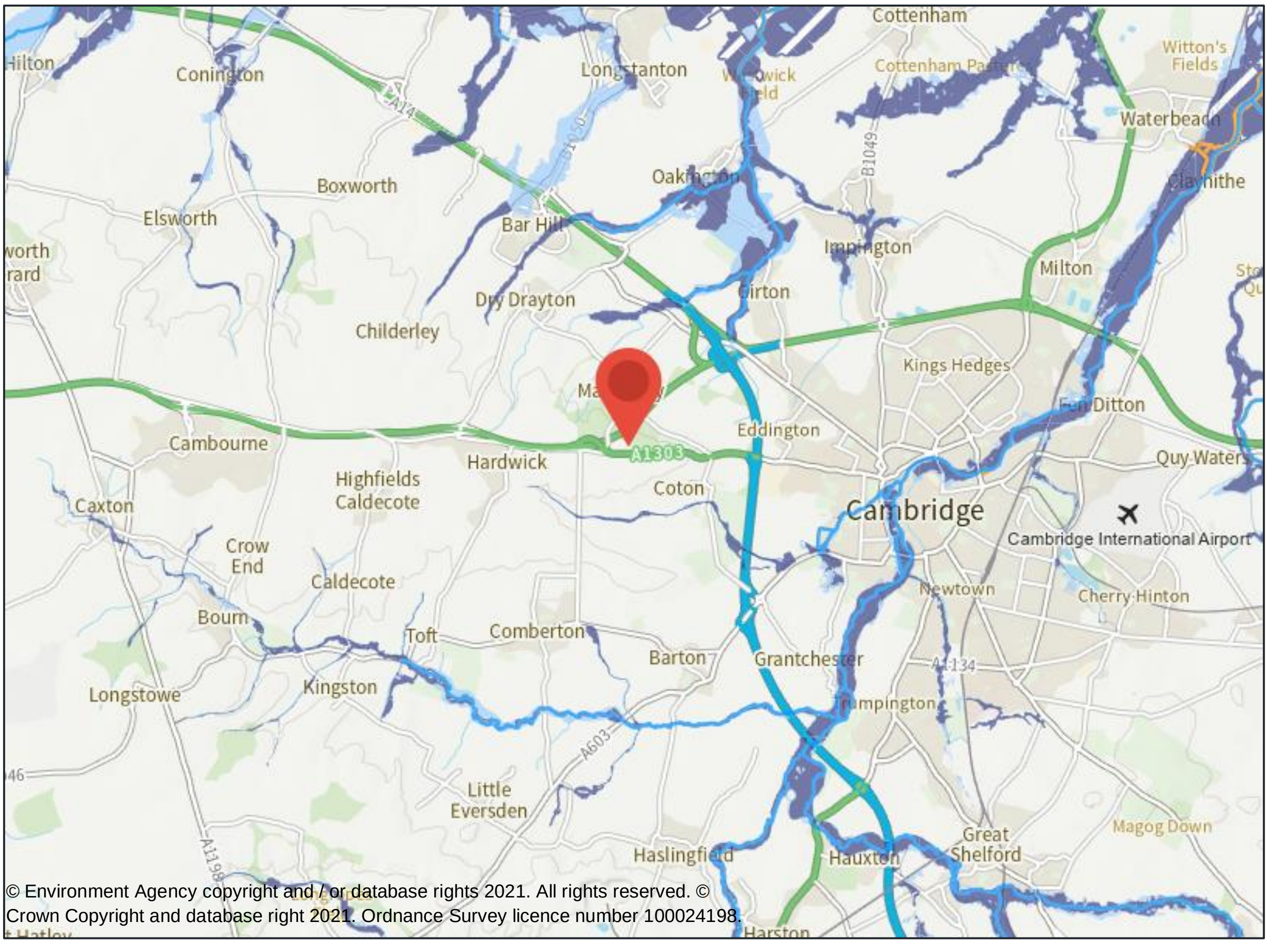
Period	Days rainfall > 1mm (1981-2010) Cambridge NIAB	Days rainfall > 1mm (1981-2010) UK
Summer	25.2	42.3
Winter	28.2	34.9
Annual	107.5	156.4

2.2.5. Some noteworthy extreme rainfall events in the East England region include:

- October 2020: Storm Alex brought strong winds to the southern half of the UK, with associated fronts bringing prolonged and widespread heavy rain. This resulted in marking the UK's wettest day on record in a daily series back to 1891 **(Ref. 3.4)**;
- August 2020: Thunderstorms affected parts of East Anglia on 16th August. A rain-gauge in Norfolk recorded a remarkable daily total of 239.9 mm, setting a new UK August daily rainfall record at an individual station. The torrential rainfall caused localised flash floods; however, flood impacts were relatively modest **(Ref. 3.5)**; and
- October 2001: A slow moving front brought heavy rainfall to the east of the UK. Records for highest rainfall reported in a single 24-hour period were broken at three weather stations around Cambridge **(Ref. 3.6)**.

2.2.6. The C2C Scheme crosses Bin Brook, located in the east between the M11 and Cambridge, however the majority of the C2C Scheme is not located in an area of flood risk, as shown in **Plate TR3-2-2**.

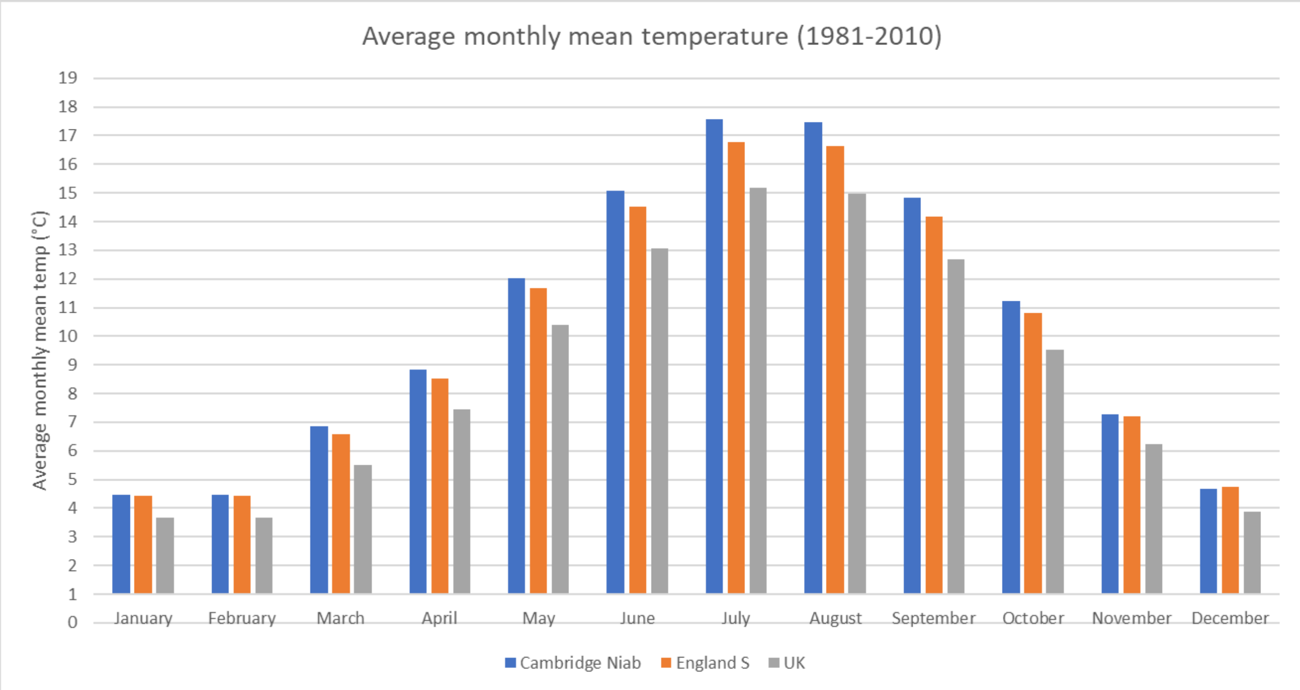
Plate TR3-2-2 - Flood Zone Map for C2C Scheme and its surroundings (Ref. 3.7)



TEMPERATURE

2.2.7. Mean annual temperature over the region depends on the altitude and to some extent proximity to the coast **(Ref. 3.1)**. **Plate TR3-2-3** shows the long-term average mean monthly temperature for the Cambridge Niab weather station, Southern England region, and the UK for the period 1981-2010. It shows that average temperatures at Cambridge weather station are consistently above regional and UK average throughout the year.

Plate TR3-2-3 - Long-term average mean monthly temperature for the Cambridge Niab weather station, Southern England region and the UK (Ref. 3.2)



EXTREME TEMPERATURE

2.2.8. **Table TR3-2-2** shows the average maximum and minimum summer (June, July, and August) and winter (December, January, and February) temperatures recorded between 1981 and 2010 for Cambridge Niab weather station, whereby summer mean maximum and minimum temperatures are highs of 21.8°C and 11.7°C, respectively, temperature lows reach 1.6°C for winter months from 1981-2010. Data for the UK is also provided for context.

Table TR3-2-2 - Long term average of mean maximum and minimum temperature (°C) for Cambridge Niab weather station and UK for 1981-2010 (Ref. 3.2)

Period	Cambridge Niab		UK	
	Mean Maximum Temperature (°C) (1981-2010)	Mean Minimum Temperature (°C) (1981-2010)	Mean Maximum Temperature (°C) (1981-2010)	Mean Minimum Temperature (°C) (1981-2010)
Summer	21.8	11.7	18.7	10.2
Winter	7.5	1.6	6.6	0.9

2.2.9. Air frost is defined as when the air temperature falls to or below freezing point of water at a height of at least 1 m above the ground **(Ref. 3.8)**. **Table TR3-2-3** shows that from 1981-2010, the average number of air frost days was 29.0 in winter which is 8% of the total number of days in a year at Cambridge Niab weather station, and 35.5 for the UK.

Table TR3-2-3 - Average number of days of air frost for the baseline period (1981-2010) (Ref. 3.2)

Period	Days of air frost (1981-2010) at Cambridge Niab	Days of air frost (1981-2010) for the UK
Summer	0.0	0.1
Winter	29.0	35.5
Annual	44.8	57.6

2.2.10. Some noteworthy extreme temperature events include:

- July 2022: the UK experienced a brief but unprecedented extreme heatwave. A new UK and England record temperature of 40.3°C was recorded at Coningsby, Lincolnshire, breaking the previous record by 1.6°C. Across multiple stations weather station in England temperatures exceeding 40°C were recorded. This heatwave marked a milestone in UK climate history, with 40°C being recorded for the first time in the UK **(Ref 3.9)**;
- December 2021 / January 2022: the UK experienced a spell of exceptionally mild weather for the time of year. Daily maximum temperatures reached 15 to 16°C quite widely, and the UK recorded both its warmest New Year's Eve and its warmest New Year's Day on record with 16.8°C on 31 December 2021. Overcast conditions at night also resulted in exceptionally high daily minimum temperatures, remaining widely above 10°C. Several stations, with 100+ year records, recorded both their mildest December and mildest January nights **(Ref. 3.10)**;
- August 2020: Southern England experienced a heatwave during early August 2020 as hot, humid air moved north from the near continent. Temperatures exceeded 34°C across parts of the south-east for six consecutive days and there were several tropical nights with overnight temperatures remaining above 20°C. This was one of the most significant heatwaves to affect Southern England in the last sixty years **(Ref. 3.11)**; and

- July 2019: The UK experienced a short but exceptional heatwave in late July. On 25th, temperatures across eastern England widely reached 35 to 36°C and a temperature of 38.7°C was recorded at Cambridge Botanic Garden, which was then a new UK temperature record. The rail network was severely affected across south-east England with train cancellations and main lines closed out of London due to concerns about rail buckling. Damage occurred to overhead electric wires as they sagged in the heat, and trackside vegetation caught fire in several locations. The exceptionally hot weather made conditions difficult, particularly for the frail and elderly **(Ref. 3.12)**.

HUMIDITY

2.2.11. The relative annual average humidity for the Cambridge Niab weather station is recorded as averaging approximately 74-78% in the summer and 88-86% in the winter. In the surrounding area, summer average humidity is generally higher in coastal areas (76-80% on the south and east coast) and lower (72-78%) in urban areas. During winter, the majority of southern and eastern England has average annual humidity levels of 82-88% **(Ref. 3.2)**.

SNOW AND ICE

2.2.12. Snow forms when temperatures are low and there is moisture in the atmosphere. Precipitation falls as snow when the air temperature is below 2°C. The heaviest of snowfalls tends to occur when temperature is between 0 and 2°C. When the temperature is warmer than 2°C snow will fall as sleet.

2.2.13. The annual average number of days in East England with snow falling ranges from under 20 in the south-east to over 30 on higher ground. The average number of days every year with snow lying is less, varying from about 6 to 15. Some of the snow events that the region has experienced include:

- February 2021: The UK experienced a week of severe winter weather from 7 to 13 February, with easterly winds drawing a bitterly cold airflow from eastern Europe. Storm Darcy brought some strong winds and heavy snow to parts of south-east England, while persistent snow showers resulted in significant accumulations across eastern England and Scotland. Snow and ice caused widespread travel disruption, with roads closed across many eastern coastal counties **(Ref. 3.13)**; and
- February / March 2018: The UK experienced a spell of severe winter weather with very low temperatures and significant snowfalls from late February to early March 2018. Daytime temperatures remained widely below freezing on 28 February to 1 March with a strong east wind and significant accumulations of snow across much of the country; the Met Office issued two Red Warnings for snow. This was the most significant spell of snow and low temperatures for the UK since December 2010 **(Ref. 3.14)**.

WIND AND STORMS

2.2.14. East England is one of the more sheltered parts of the UK, since the windiest areas are to the north and west, closer to the track of Atlantic storms. The strongest winds are associated with the passage of deep areas of low pressure close to or across the UK. The frequency and strength of these depressions is greatest in the winter half of the year, especially from December to February, and this is when mean speeds and gusts (short duration peak values) are strongest.

2.2.15. Winds are usually stronger by day than by night due to increased turbulence caused by temperature rise, resulting in higher average speeds and more gusty winds. Periods of very light or calm winds are more prevalent inland, with coastal areas having similar wind directions to inland locations but higher wind speeds.

2.2.16. Despite generally less windy conditions, Eastern England has the greatest frequency of tornadoes in the UK. A tornado is a violently rotating column of air, caused by the rapid displacement of warm moist air by cold dense air often associated with the occurrence of active cold fronts. On average, 33 tornados are reported each year in the UK. Both the longest track tornado and the largest outbreak of tornadoes in the UK occurred in Eastern England.

2.2.17. A 'day of gale' is defined as a day on which the wind speed attains a mean value of 34Kt or more over any period of ten minutes. Notable storms and gales affecting the region include:

- February 2022: Three named storms (Dudley, Eunice and Franklin) affected the UK within the space of a week, the first time this has occurred for since storm naming was introduced in 2015/2016. Two rare red warnings were issued for Storm Eunice, the most severe and damaging storm to affect England and Wales since February 2014. Winds gusted at over 70Kt (81mph) in exposed coastal locations **(Ref. 3.15)**;
- December 2020: Storm Bella was a large, deep area of low pressure dominating the North Atlantic, bringing heavy rain and very strong winds sweeping across England and Wales overnight 26 to 27 December **(Ref. 3.16)**; and
- August 2020: The UK experienced a turbulent spell of weather in late August 2020 with a strong jet stream bringing deep areas of low pressure. Storms Ellen (19th to 21st) and Francis (25th) brought wind gusts of 40 to 50Kt across inland areas and 50 to 60Kt across exposed coastal locations **(Ref. 3.17)**.

2.3 FUTURE CLIMATE PROJECTIONS

2.3.1. The UKCP18 **(Ref. 3.22)** provide data on projected change in climate variables for the UK. The UKCP18 are the most up-to-date projections of climate change for the UK, providing projections until the end of the twenty-first century. The Climate Risk Indicators ('CRI') **(Ref 3.18)** developed by Nigel Arnell *et al*., as part of the UK Climate Resilience Programme has been used to infer this assessment. The CRI utilises the UKCP18 projections and allows for a range of climate related indicators (including but not limited to, Met Office heatwaves and heat stress).

2.3.2. UKCP18 includes probabilistic projections of a range of climate variables for different emissions scenarios, termed representative concentration pathways ('RCPs') and for a range of time slices to the end of the century. To address the full range of climate model uncertainty the results are provided as 50th percentiles (median values) and the estimate projections are presented against baseline levels of 1981-2010s (based on model data).

2.3.3. The RCP8.5 scenario has been used to infer this assessment. RCP8.5 is a high emissions' scenario which combines assumptions about high population and relatively slow income growth with modest rates of technological change and energy intensity improvements.

2.3.4. The future baseline has been presented for the Local Authority Areas of Cambridge and South Cambridgeshire for the 2030s, 2050s, and 2080s, to identify the anticipated climate conditions over the design life (minimum of 50 years) of the C2C Scheme.

2.3.5. Where data is not available at the Local Authority Area, this has been noted in the text and the East England regional data has been used.

PRECIPITATION

2.3.6. Climate change is projected to lead to wetter winters and drier summers, however natural variations, including extreme events such as storms, will continue to punctuate these trends. The projected changes to the average winter and summer rainfall for the 2030s, 2050s and 2080s, compared to 1981-2010 (i.e., the anomalies) under RCP8.5 are summarised in **Table TR3-2-4**. The central estimate (50th percentile) indicates that winter becomes wetter in the short-term by 5.7%, in the medium-term by 10.2%, and in the long-term by 18.1%. Summers are 9.4% drier in the short-term, 19.1% drier in the medium-term and 31.1% drier in the long-term. More extreme events (90th percentile) show an increase in precipitation of 22.2% by 2050s in winter, and a slight increase of 0.7% by the 2050s in summer.

Table TR3-2-4 - Projected change in rainfall (%) in the South Cambridgeshire Local Authority Area under RCP8.5 (Ref. 3.18)

Season	Percentile	2030s	2050s	2080s
Winter	10th	-1.6	-0.4	2.9
	50th	5.7	10.2	18.1
	90th	13.5	22.2	35.5
Summer	10th	-24.6	-37.5	-52.5
	50th	-9.4	-19.1	-31.0
	90th	5.7	0.7	-5.8

2.3.7. Another indicator for precipitation is soil moisture and the potential impact this may have on structural stability of foundation systems, buildings and infrastructure, as well as the sustenance of new planting. The projected changes to the average winter and summer soil moisture for the 2030s, 2050s and 2080s, compared to 1981-2010 (i.e., the anomalies) for East England region are summarised in **Table TR3-2-5**. The central estimate (50th percentile) indicates that during winter soil moisture decreases by 5.9% in the short term, by 8.0% in the medium-term and by 10.8% in the long-term. Summer soils are projected to be 13.4% drier in the short-term, 20.7% drier in the medium-term and 29.8% drier in the long-term.

Table TR3-2-5 - Projected change in soil moisture (%) for East England under RCP8.5 (Ref. 3.18)

Season	Percentile	2030s	2050s	2080s
Winter	10th	-10.9	-14.6	-16.0
	50th	-5.9	-8.0	-10.8
	90th	1.3	-1.2	-3.3
Summer	10th	-24.6	-31.1	-39.5
	50th	-13.4	-20.7	-29.8
	90th	-7.0	-16.8	-24.7

EXTREME PRECIPITATION

2.3.8. The projected change in the number of months per year at least as wet as the baseline period (1981-2010) under RCP8.5 are summarised in **Table TR3-2-6**. This indicator provides the projected trend in record breaking weather events. In the baseline scenario for the projections, the record-breaking wettest month occurred on average 0.03 months per year. The central estimate (50th percentile) indicates that this will double by the 2050s (0.05 months per year) and be over three times more common by the 2080s (0.09 months per year).

Table TR3-2-6 - Number of months per year in the South Cambridgeshire Local Authority Area at least as wet as the wettest month between 1981 and 2010 (Ref. 3.18)

Percentile	2030s	2050s	2080s
10th	0.03	0.01	0.03
50th	0.06	0.05	0.09
90th	0.11	0.11	0.18

TEMPERATURE

2.3.9. In general, UKCP18 projects that climate change will lead to a trend of warmer winters and hotter summers, increasing the frequency and intensity of extreme heat events. The projected changes to average summer and winter temperatures for South Cambridgeshire Local Authority Area are summarised in **Table TR3-2-7**. The central estimate (50th percentile) shows an increase in winter temperatures by 0.1°C in the short-term, 1.7°C in the medium-term and 3.0°C in the long-term. The 90th percentile indicates an increase of 4.9°C in winter temperature by the end of the century. Summer temperatures increase by 1.4°C in the short term, 2.6°C in the medium term and 4.9°C in the long term. The 90th percentile indicates an increase of 7.5°C in summer temperatures by the end of the century.

Table TR3-2-7 - Projected change in average temperature (°C) in South Cambridgeshire Local Authority Area

Season	Percentile	2030s	2050s	2080s
Winter	10th	0.1	0.7	1.3
	50th	0.1	1.7	3.0
	90th	1.9	2.8	4.9
Summer	10th	0.7	1.2	2.5
	50th	1.4	2.6	4.9
	90th	2.3	4.1	7.5

EXTREME TEMPERATURE

2.3.10. The projected change in the number of months per year at least as hot as the hottest month in the baseline period (1981-2010) under RCP8.5 are summarised in **Table TR3-2-8.** This indicator provides the projected trend in record breaking weather events. In the baseline scenario for the projections, the record-breaking hottest month occurred on average 0.03 months per year. The central estimate (50th percentile) indicates that there will be an increase in the number of months per year to 0.78 by the 2050s and to 2.02 months per year by the 2080s.

Table TR3-2-8 - Number of months per year in South Cambridgeshire Local Authority Area at least as hot as the hottest month between 1981 and 2010 (Ref. 3.18)

Percentile	2030s	2050s	2080s
10th	0.1	0.2	0.7
50th	0.2	0.8	2.0
90th	0.5	1.6	3.4

2.3.11. The maximum air temperature for summer in the 2080s at the 50th percentile under RCP 8.5 is projected to reach 39.15°C in Cambridgeshire.

2.3.12. Other indicators for extreme temperature events include heatwaves, heat stress, road melt risk (an indicator for melting of asphalt roads) and growing season lengths.

Heatwave

2.3.13. A heatwave is an extended period of hot weather relative to the expected conditions of the area at that time of year **(Ref. 3.19)**. A UK heatwave is defined as the maximum temperature above a region-specific threshold which lasts for at least three consecutive days **(Ref. 3.20)**. The present-day heatwave threshold for Cambridgeshire is 28°C. The intensity, frequency and duration of heatwaves are projected to increase under future warming. **Table TR3-2-9** shows the projected number of heatwave events per year under RCP8.5 for the South Cambridgeshire Local Authority Area compared to the baseline scenario (1981-2010) which is 1.0. The central estimate (50th percentile) indicates that there will be an increase in the number of events per year to 3.3 by the 2050s and to 4.9 by the 2080s.

Table TR3-2-9 - Number of heatwave events per year in South Cambridgeshire Local Authority Area (Ref. 3.18)

Percentile	2030s	2050s	2080s
10^{th}	1.4	1.7	3.1
50^{th}	2.0	3.3	4.9
90^{th}	2.8	4.7	6.4

Heat stress

2.3.14. Heat stress occurs when the body's means of controlling its internal temperature starts to fail. Factors contributing to this include air temperature and humidity as well as work rate and clothing worn. As temperatures are projected to increase, the risk of heat stress in outdoor environment are projected to increase **(Ref. 3.21)**. In this case wet bulb global temperature (combining temperature and humidity) exceeding threshold of 25°C is used as a proxy for heat stress **(Ref. 3.20)**. For South Cambridgeshire Local Authority Area, heat stress ranges from 0.49 to 2.3 days per year (10^{th} – 90^{th} percentile) in the short-term, 1.01 to 7.17 days per year in the medium-term and 3.35 to 27.35 days per year in the long-term.

Road melt risk

2.3.15. Extreme heat (where the maximum temperatures is above 26°C) can result in damage to infrastructure in the form of melting of asphalt road surfaces. For South Cambridgeshire Local Authority Area, at present, these occur on average 19.29 days per year. In the short term, the number of days per year is projected to be between 24.46 and 41.98 (10^{th} – 90^{th} percentile), between 29.76 and 64.52 in the medium term, and between 45.30 and 104.05 in the long term.

Growing season length

2.3.16. Shifting seasons are directly linked to warmer global temperatures. These environmental changes cause plants to grow for a longer period of time during each growing season. Growing season length is defined as the duration (in days) between the start of the growing season and the first of five consecutive days with an average temperature of <5.6°C. The current average growing days in the South Cambridgeshire Local Authority Area are 248.42 days. Under RCP8.5 the season is expected to increase in the short term to 254.51 to 282.33 days (10^{th} – 90^{th} percentile), in the medium term to 265.65 to 298.51 days, and in the long term to 280.02 to 331.57 days.

SNOW AND ICE

2.3.17. With regards to future changes, rising winter temperatures are likely to reduce the amount of precipitation that falls as snow. For RCP8.5, the regional (12km) and local (2.2km) projections show a decrease in both falling and lying snow across the UK relative to 1981-2000 reference period **(Ref.**

3.22). However, this information should be used with caution, as the projections provide a narrow range of future outcomes and do not sample the full range of uncertainties.

2.3.18. An indicator for this is road accidents due to ice, where days with a minimum temperature is less than 0°C. For South Cambridgeshire Local Authority Area, at present, these occur on average 49.36 days per year. In the short term, the number of days per year is projected to be between 27.54 to 44.43, between 19.06 to 37.73 in the medium term, and between 9.01 and 29.37 in the long term.

HUMIDITY

2.3.19. The central estimate (50th percentile) in **Table TR3-2-10** shows a slight decrease in humidity in winter by 0.3% in the short term, and 0. 6% in the medium term. Summer humidity decreases by 6.1% in the short term and by 9.6% in the medium term under RCP8.5. Data for Humidity is available at a 12km resolution scale in UKCP18 and does not extend to the 2080s.

Table TR3-2-10 - Change in humidity (%) for the 2030s and 2050s

Season	Percentile	2030s	2050s
Winter	10th	-2.5	-2.9
	50th	-0.3	-0.6
	90th	1.9	1.6
Summer	10th	-11.9	-15.2
	50th	-6.1	-9.6
	90th	-0.8	-3.9

WIND AND STORMS

2.3.20. UKCP18 guidance depicts a wide spread of future changes in mean surface wind speed, however, there is large uncertainty in projected changes in circulation over the UK, and natural climate variability contributes much of this uncertainty **(Ref. 3.23**). The Global projections over the UK show - an increase in near surface wind speeds over the UK for the second half of the 21st century for the winter season when more significant impacts of wind are experienced.

2.3.21. Studies **(Ref. 3.24, 3.25)** relating to future projections of storms suggest that climate-driven storm changes are less distinct in the northern than southern hemisphere. However, such is the wide range of inter-model variation, there is low confidence in the direction of future changes in the frequency, duration or intensity of storms affecting the UK.

3 METHODOLOGY SUMMARY

3.1 STUDY AREA

3.1.1. The focus of the Climate Resilience assessment is the vulnerability of the C2C Scheme to climate change, (rather than the impact of C2C Scheme on the environment). The study area for the assessment of permanent risks is the area within the Order limits of deviation ('LOD').

3.2 SCHEME RECEPTORS

3.2.1. The following key receptors have been identified for the operational phase of C2C Scheme through the consideration of their vulnerability to climate hazards by applying professional judgement:

- New and existing busway including junctions;
- Emergency access and maintenance track carrying shared use path;
- Embankments;
- Structures (bridges, under/overpasses);
- Drainage features (culverts, detention ponds / SuDS);
- Travel hub (parking areas and building);
- Traffic control / signage / other electrical infrastructure;
- Landscaping / habitat creation; and
- End users of the C2C Scheme (passengers, employees, maintenance contractors).

3.3 METHODOLOGY

BASELINE DATA COLLECTION

3.3.1. No site visits or surveys were required for this assessment. Baseline data has been provided through desk-based study.

3.3.2. The assessment has been informed on existing and projected change in climate variables derived from the following sources:

- State of the UK Climate 2021 (2022) (**Ref. 3.26**) (existing baseline);
- Met Office Regional Climate Profile for Eastern England (**Ref. 3.27**) (existing baseline);
- UK Climate Projections 2018 ('UKCP18') (**Ref. 3.28**) (future baseline);
- UK Climate Resilience Programme (future baseline) (**Ref. 3.29**)
- IEMA Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation (Ref. **3.30**); and
- Design Manual for Roads and Bridges ('DMRB') LA 114 Climate (**Ref. 3.31**).

ASSESSMENT METHODOLOGY

3.3.3. The significance of effects has been determined by considering the consequence and the likelihood of potential impacts associated with changes in climate variables on the scheme receptors. Likelihood and consequence have been qualitatively assessed using the descriptions in **Table TR3-3-1** and **Table TR3-3-2**, informed by the existing and projected baseline. These descriptions are adapted from DMRB LA 114 **(Ref. 3.31).** The likelihood definitions depend on the lifetime of the Scheme's components and therefore would vary. The anticipated lifespan of the C2C scheme is 60 years with the bridges having a lifespan of 100 years. For the purposes of the assessment, a 60 year design life has been applied.

Table TR3-3-1 - Measure of Likelihood

Measure of likelihood	Description
Very high	The event occurs multiple times during the lifetime of the project (60 years) e.g. approximately annually.
High	The event occurs several times during the lifetime of the project (60 years) e.g. approximately once every 5 years.
Medium	The event occurs limited times during the lifetime of the project (60 years) e.g. approximately once every 15 years.
Low	The event occurs during the lifetime of the project (60 years) e.g. once in 60 years.
Very low	The event can occur once during the lifetime of the project (60 years).

Table TR3-3-2 - Measure of Consequence

Measure of Consequence	Description
Very large adverse	Permanent damage and complete loss of service. National level (or greater) disruption lasting more than one week. Early renewal of infrastructure >90%. Severe health effects and/or fatalities. Extreme financial loss. Very significant loss to the environment requiring remediation and restoration.
Large adverse	Extensive infrastructure damage and severe loss of service. National level disruption to strategic route(s) lasting more than one day but less than one week, or regional level disruption to strategic route(s) lasting more than one week. Early renewal of infrastructure 50-90%. Permanent physical injuries and/or fatalities. Major financial loss. Significant effect on the environment, requiring remediation.
Moderate adverse	Limited infrastructure damage and loss of service with damage recoverable by maintenance or minor repair. Regional level disruption to strategic route(s) lasting more than one day but less than one week. Moderate financial losses. Adverse effects on health and/or the environment.
Minor adverse	Localised infrastructure disruption or loss of service. Regional level disruption to strategic route(s) lasting less than one day. No permanent damage, minor restoration work required. Small financial losses and/or slight adverse health or environmental effects.
Negligible	No infrastructure damage, minimal adverse effects on health, safety and the environment or financial loss. Little change to service and disruption to an isolated section of a strategic route lasting less than one day.

3.3.4. The assessment of likelihood and consequence (and therefore significance) has taken into account the embedded mitigation. Embedded mitigation has been identified through engagement with the project design team.

3.3.5. The likelihood and consequence have been combined to assess the significance of effects on the affected receptors, as shown in **Table TR3-3-3**. The assessment is qualitative and based on expert judgement derived from the knowledge of similar schemes, engagement with the wider Project team and review of relevant literature.

Table TR3-3-3 - Significance rating matrix

Measure of consequence of hazard occurring	Measure of likelihood				
	Very Low	Low	Medium	High	Very High
Very Large	Not Significant	Significant	Significant	Significant	Significant
Large	Not Significant	Not Significant	Significant	Significant	Significant
Moderate	Not Significant	Not Significant	Significant	Significant	Significant
Minor	Not Significant	Not Significant	Not Significant	Not Significant	Not Significant
Negligible	Not Significant	Not Significant	Not Significant	Not Significant	Not Significant

IN-COMBINATION CLIMATE IMPACTS

3.3.6. Aligning to the IEMA Guide (**Ref. 3.30**), each of the environmental topic specialists have been consulted to identify the potential for climate change to exacerbate or ameliorate the potential effects identified within their Technical Report assessments. This has been undertaken through the technical specialists reviewing the future climate projections (outlined in Section 2 of this Technical Report) and using professional judgement to ascertain any worsening or improvement to the effects relevant to their specialist topic.

4 ASSUMPTIONS AND EMBEDDED MITIGATION

4.1 ASSUMPTIONS

4.1.1. The assumptions made in the assessment and the potential limitations include:

- The Climate Risk Indicators and UKCP18 projections have been used to infer future changes in a range of climate variables that may affect the resilience of the C2C Scheme to climate change. At the time of writing, these represent the most up-to-date representation of future climate in the UK;
- There are inherent uncertainties associated with climate projections and they are not predictions of the future. It is possible that future climate will differ from the future baseline climate against which the resilience of the Proposed Scheme has been assessed, depending on global emissions over the next century. A ‘high’ emissions scenario (RCP 8.5) using the 2080s time slice (2070-2099 - the longest temporal scale available through UKCP18) has been used to develop the baseline against which resilience has been assessed. This is consistent with the precautionary principle (i.e., ‘worst case’ scenario);
- Any further research, analysis or decision-making should take account of the accuracies and uncertainties associated with climate projections. It is also important to note that the analysis is based on selected observational data, the results of climate model ensembles and a selected range of existing climate change research and literature available at the time of the assessment. Any future decision-making based on this analysis should seek to identify whether the range of literature, evidence and research available has changed in the interim; and
- The assessment of impacts and evaluation of significance has been using the preliminary design of the C2C Scheme. The assessment is made on the basis that the embedded mitigation (set out in Section 4) will be fully incorporated into the design, monitoring and maintenance of the C2C Scheme.

4.2 EMBEDDED MITIGATION

4.2.1. The detailed design will take account of the climate hazard and impacts set out in **Table TR3-4-1** and mitigate the impacts for the design life of the C2C Scheme. This aligns with DMRB LA114 (**Ref. 3.31**) principles for design and mitigation measures to minimise the Scheme’s vulnerability to projected climate change. Furthermore, Cambridgeshire County Council’s Climate Change and Environment Strategy (**Ref. 3.32**) sets out the need for highways management to fully consider, and where possible implement, designs with greater adaptability to climate impacts. The detailed design will need to demonstrate that the C2C Scheme is resilient to the projected changes in climate according to the projected future climate scenarios described here and, in the ES, and in particular:

- A decrease in summer precipitation by 18% by the 2080s, an increase in winter precipitation by 31% by the 2080s, and increased frequency of extreme precipitation events;
- increase in average temperatures by 5°C in the summer and 3°C in winter by the 2080s; increase in maximum summer temperature to 39°C; and increase in frequency of heatwaves; and
- increased intensity and frequency of high winds and storms.

4.2.2. **Table TR3-4-1** outlines the aspects that will need to be accommodated by the detailed design in order to mitigate these climate hazards and impacts.

4.2.3. Monitoring and maintenance of the components of the Scheme throughout its operational design life are required to ensure that any weather/climate-related impacts are identified, and appropriate measures are taken to ensure resilience of the scheme/infrastructure for users. This aligns with DMRB LA114 monitoring principles to ensure the project design is operating as intended, DMRB CS450 (**Ref. 3.33**) detailing inspection of highway structures, and Cambridgeshire County Council's Climate Change and Environment Strategy to understand the risk to infrastructure and develop plans to reduce the impacts climate change could bring. These will be integrated as part of other maintenance and monitoring arrangements, and will include, from a climate perspective:

- a description the climate hazards that are most likely to present a hazard to the operation of the scheme for its entire design life;
- a monitoring schedule – periodic and incidents including extreme weather events;
- an inspection form containing weather-related criteria to be checked and recorded during emergency and periodic inspections; and
- how weather-related incidents and damage are to be rectified by maintenance activities.

4.2.4. **Table TR3-4-1** sets out the embedded mitigation measures that have been incorporated into the design of the C2C Scheme. The assessment of effects takes into account mitigation embedded in the C2C Scheme's design.

Table TR3-4-1 - Potential impacts and embedded mitigation

Climate Variable	C2C Element and Users Affected	Potential Impact	Embedded mitigation	Evidence of Commitment
Precipitation Changes in annual average: ▪ Projected decrease in summer precipitation by 18% by the 2080s; and ▪ Projected increase in winter precipitation by 31% by the 2080s. Increased frequency of extreme precipitation events.	**Scheme Assets** ▪ New and existing busway including junctions; ▪ Shared use path; ▪ Structures (bridges, under/overpasses); ▪ Travel hub (parking areas and building); and ▪ Drainage features (culverts, detention ponds / SuDS etc).	▪ Flooding resulting in damage to roads and structures; and ▪ Overwhelmed drainage leading to surface water flooding.	The Scheme will be designed to be safe and dry (from fluvial, pluvial, groundwater and surface water runoff from the scheme during the design flood event, including effects of scour). As detailed in the Flood Risk Assessment, the climate change allowances are: ▪ 19% increase in peak river flow for the assessment of risk to the C2C Scheme, assessment of risk to third parties, design of the watercourse crossings and design of other required mitigation if required; and ▪ 35% increase in the 3.33% annual exceedance probability (AEP) rainfall event and a 40% increase in the 1% AEP rainfall event. Measures include in the design in relation to flooding and drainage include: ▪ The fluvial design event is the 1 in 100 year plus climate change (19%); ▪ Route to be located above the 1 in 100 year plus 19% climate change flood level. Bridge design drawings detail this at Bin Brook Crossing; ▪ Attenuation pond and basins for storm water storage and attenuate discharge to the drainage network. Detention	▪ Flood modelling and Flood Risk Assessment; ▪ Scheme design; ▪ Drainage Strategy; and ▪ Operational maintenance and monitoring arrangements.

Climate Variable	C2C Element and Users Affected	Potential Impact	Embedded mitigation	Evidence of Commitment
			basins/ponds will be confirmed at detailed design and should be sized to meet the 1% AEP rainfall event with a 300 mm freeboard. For the 1% AEP rainfall event, plus 40% for climate change, runoff volumes will be contained within detention basins/ponds. As such exceedance flows arising from the busway are proposed to be contained within the proposed busway corridor; ▪ Attenuation will be provided within swales, which will be designed to ensure a 100 mm freeboard is maintained; ▪ Assessments of the volumes of attenuation storage have been carried out for each catchment. These are based on the 1% AEP plus 40% climate change rainfall event and allowable discharge rate for the site; ▪ Other minor watercourse crossings have been design to the 1 in 1000 year event (0.1%AEP) which accounts for flows greater than the 1 in 100 year plus 40% for climate change allowance; ▪ At the travel hub, surface water runoff will be directed eastwards to a detention pond before being discharged to Callow Brook. The preferred SuDS	

Climate Variable	C2C Element and Users Affected	Potential Impact	Embedded mitigation	Evidence of Commitment
			options for this area will be confirmed at detailed design stage and will be designed to accommodate the projected changes in rainfall; ▪ The Drainage Strategy assesses the existing runoff rates and volumes for the 1% AEP. Runoff rates will be agreed with the Lead Local Flood Authority at the next design stage; ▪ For the 1% AEP rainfall event +40% climate change, some flooding is permitted, however, it is managed such that it doesn't enter buildings or disrupt emergency routes; and ▪ Landscaping proposals will also help reduce surface water runoff and burden in the watercourse network during heavy rainfall events. Regular monitoring and maintenance of the drainage features will be implemented for the operational design life, including inspections prior to and after extreme rainfall events.	
	Scheme Assets ▪ Embankments	▪ Subsidence resulting in damage to roads and structures (from drought or increased precipitation / flooding).	At preliminary design the embankment slope gradients are assessed for the fill available at the site. At detailed design the embankment slide design will take into consideration how embankment drainage is design to accommodate adverse weather and impacts on the slope. The	▪ Detailed design; and ▪ Operational maintenance and

Climate Variable	C2C Element and Users Affected	Potential Impact	Embedded mitigation	Evidence of Commitment
			main considerations would relate to the softening of the slope from saturation and erosion of the slope from surface water runoff. Should these considerations be identified as a risk, geotechnical interventions would be adopted. Subsidence or settlement from changes to the ground conditions are considered less of a risk due to the clay soils at the M11 crossing site. Measures to assess the risk at detailed design will be undertaken to assess the requirement for incorporating a drainage layer to reduce groundwater pressures at the base of the embankment and to stiffen the soils. Regular monitoring and inspection of embankments after extreme precipitation events will be implemented to assess impacts or damage caused by climate hazards.	monitoring arrangements.
	Scheme Assets ▪ Traffic control / signage / other electrical infrastructure.	▪ Damage to electrical equipment from water ingress resulting in failure of equipment.	The projected changes in precipitation will be allowed for in the detailed design to ensure electrical equipment is protected from water ingress resulting in damage and failure. Future maintenance and replacement of electrical equipment will ensure prevention of water ingress measures are included.	▪ Detailed design; and ▪ Operational maintenance and monitoring arrangements.

Climate Variable	C2C Element and Users Affected	Potential Impact	Embedded mitigation	Evidence of Commitment
			Regular monitoring and inspection of electrical equipment after extreme precipitation events will be implemented to assess impacts or damage caused by climate hazards.	
	Scheme Assets ▪ Landscaping / habitat creation	▪ Damage to / loss of planted landscaping and habitat (from flooding or from drought conditions); and ▪ Longer growing season, more vigorous vegetation growth in spring and autumn resulting in increased maintenance.	Planting proposals will be developed as part of the detailed design. As part of the TWAO deliverables a sample planting list will suggest a variety of native species, and non-native species ensuring a robust and diverse palette. At detailed design the landscaping scheme will ensure applicability of planting to projected climate impacts and their citing within the Scheme. Planted Dry/Wet Basins and swales are proposed with planting that can withstand dry and wet conditions and attenuation capabilities. Designs to maximise self-sustaining habitats such as woodland or grassland and limiting where possible trees that are being proposed on bunding/slopes to avoid any subsidence or dry-outs. A Landscape management plan will be provided to ensure vegetation is appropriately managed to reduce risks of damage and detail an irrigation and maintenance strategy.	▪ Landscape planning; ▪ Scheme design; and ▪ Operational maintenance and monitoring arrangements.

Climate Variable	C2C Element and Users Affected	Potential Impact	Embedded mitigation	Evidence of Commitment
	End users	▪ Safety risks and disruption to end users from flooding or aquaplaning; and ▪ Potential for emergency access vehicle to have access issues to the development from localised flooding.	The Scheme will be designed to be safe and dry (from fluvial, pluvial, groundwater and surface water runoff from the scheme during the design flood event. The detailed design will incorporate swales and detention basins / ponds with climate change allowance and restricted flows to mitigate flooding. See details under Scheme Assets above). The busway will be kerb edged, but with drop kerbs provided at regular intervals to allow for discharge into a filter strip and then to a swale network. Swales will provide attenuation and will direct surface water runoff to existing ditches or local watercourses, or to detention ponds introduced as part of the scheme. As detailed above (under Precipitation, Scheme Assets), the swales and attenuation ponds are design with climate change allowance. The regular monitoring and maintenance of the drainage features will be implemented for the operational design life.	▪ Flood modelling and Flood Risk Assessment; ▪ Scheme design; ▪ Drainage Strategy; and ▪ Operational maintenance and monitoring arrangements.
Temperature Change in annual average temperature	**Scheme Assets** ▪ New and existing busway including junctions; ▪ Shared use path;	▪ Deformation and/or melting of surfaces resulting in damage and increased maintenance; and ▪ Increase in thermal expansion of structure joints compromising	Projected changes in temperature will be allowed for in the detailed design to specify materials which are resilient to the projected temperatures and mitigate damage from deformation or expansion.	▪ Detailed design; and ▪ Operational maintenance

Climate Variable	C2C Element and Users Affected	Potential Impact	Embedded mitigation	Evidence of Commitment
▪ Projected increase in summer temperatures by 5°C by the 2080s; ▪ Projected increase in winter temperatures by 3°C by the 2080s; and ▪ Maximum air temperature in summer reaching 39.15°C by the 2080s. Increased frequency of heatwave events	▪ Structures (bridges, under/overpasses); and ▪ Travel hub (parking areas and building).	structural integrity leading to increased maintenance.	Regular monitoring and inspection of materials after extreme temperature events will be implemented to assess impacts or damage caused by climate hazards.	and monitoring arrangements.
	Scheme Assets ▪ Embankments; and ▪ Structures (bridges, under/overpasses).	▪ Shrinking and cracking of soils resulting in damage to infrastructure and increased maintenance.	Projected changes in temperatures will be allowed for in the detailed design for embankments to mitigate impacts from changes in ground conditions which could cause potential failure of embankments or damage to structures. Subsidence or settlement from changes to the ground conditions are considered less of a risk due to the clay soils at the M11 crossing site. Measures to assess the risk will be taken at detailed design stage. The design will maximise self-sustaining habitats such as woodland or grassland and limiting where possible trees that are being proposed on bunding/slopes to avoid any subsidence or dry-outs. Regular monitoring and inspection of embankments after extreme temperature events will be implemented to assess impacts or damage caused by climate hazards.	▪ Detailed design; ▪ Landscape planning; and ▪ Operational maintenance and monitoring arrangements.
	Scheme Assets	▪ Faster rate of deterioration of materials from increase in UV	Projected changes in temperatures will be allowed for in the detailed design	▪ Detailed design; and

Climate Variable	C2C Element and Users Affected	Potential Impact	Embedded mitigation	Evidence of Commitment
	▪ Traffic control / signage / other electrical infrastructure.	radiation (for example, brittleness and fading), causing damage and requiring early replacement; and ▪ Risk of fire resulting in power outage, disruption and increased maintenance.	specification to ensure electrical equipment is protected from extreme temperatures and UV rays by positioning out of direct sunlight where practicable. Regular monitoring and inspection of electrical equipment after extreme temperature events will be implemented to assess impacts or damage caused by climate hazards.	▪ Operational maintenance and monitoring arrangements.
	Scheme Assets ▪ Landscaping / habitat creation.	▪ Loss of vegetation cover due to scorching leading to destabilisation; and ▪ Longer growing season, more vigorous vegetation growth in spring and autumn requiring increased maintenance.	Planting and ground materials will be developed as part of the detailed design. As part of the TWAO deliverable design layouts allow for drought-tolerant planting to be implemented. Tree planting providing shading is proposed near crossings or dwelling points on the shared use path providing natural cooling. A Landscape management plan will be provided to ensure vegetation is appropriately managed to reduce risks of damage and provide a maintenance strategy.	▪ Landscape planning; ▪ Scheme design; and ▪ Operational maintenance and monitoring arrangements.
	End users	▪ Stopping of services due to asset failure; ▪ Overheating of electronic equipment and fire; and	Projected changes in temperature will be allowed for in the detailed design specification to ensure electrical equipment is protected from extreme temperatures by positioning out of direct	▪ Detailed design; and ▪ Operational maintenance and

Climate Variable	C2C Element and Users Affected	Potential Impact	Embedded mitigation	Evidence of Commitment
		▪ End users at risk from overheating, particularly in a heatwave.	sunlight where practicable, minimising the risk of electrical equipment failing and stopping services or overheating. Tree planting providing shading is proposed near crossings or dwelling points on the shared use path providing natural cooling. Regular monitoring and inspection of electrical equipment after extreme temperature events will be implemented to assess impacts or damage caused by climate hazards.	monitoring arrangements.
Wind Gales and extreme wind events due to a projected increase in the frequency and intensity of storms.	**Scheme Assets** ▪ Structures (bridges, under/overpasses).	▪ Increase wind loading on structures.	Projected changes in wind conditions will be allowed for in the detailed design for structures to mitigate impacts relating to damage from increased wind loading. Regular monitoring and inspection of structures after storms and gale events will be implemented to assess impacts or damage caused by climate hazards.	▪ Detailed design; and ▪ Operational maintenance and monitoring arrangements.
	Scheme Assets ▪ New and existing busway including junctions; ▪ Shared use path; ▪ Structures (bridges, under/overpasses);	▪ Windborne dust and debris causing clogging drainage and requiring clearing.	Regular monitoring and maintenance of the drainage features will be implemented for the operational design life.	▪ Operation and maintenance planning.

Climate Variable	C2C Element and Users Affected	Potential Impact	Embedded mitigation	Evidence of Commitment
	▪ Travel hub (parking areas and building); and ▪ Drainage features (culverts, detention ponds / SuDS etc).			
	Scheme Assets ▪ Traffic control / signage / other electrical infrastructure.	▪ Damage from high winds and rain infiltration into components resulting in power outages; and ▪ Lightning strikes causing fires.	Projected changes in wind and storm conditions will be allowed for in the detailed design to ensure electrical equipment is protected from wind and rain ingress and lightning strikes. Future maintenance and replacement of electrical equipment will ensure prevention of water ingress measures are included. Regular monitoring and inspection of electrical equipment after extreme precipitation events will be implemented to assess impacts or damage caused by climate hazards.	▪ Detailed design; and ▪ Operational maintenance and monitoring arrangements.
	Scheme Assets ▪ Landscaping / habitat creation.	▪ Vegetation damage / uprooting of trees.	Existing poplars trees by the route in Coton Orchard will be pollarded to reduce the risk of trees falling onto the road. A Landscape management plan will be provided to ensure vegetation is appropriately managed to reduce risks of damage and impact on end users.	▪ Landscape management plan; and ▪ Operational maintenance and monitoring arrangements.

Climate Variable	C2C Element and Users Affected	Potential Impact	Embedded mitigation	Evidence of Commitment
	End users	▪ Power loss resulting in disruption to services; ▪ Trees blown down and increase in debris causing safety risks or distribution to services; and ▪ Uncomfortable and/or unsafe wind speeds resulting in safety risks.	Projected changes in wind and storm conditions will be allowed for in the detailed design specification to ensure electrical equipment is protected from water ingress or damage resulting in failure and disruption to services. Future maintenance and replacement of electrical equipment will ensure prevention of water ingress measures are included. Regular monitoring and inspection of electrical equipment after extreme precipitation events will be implemented to assess impacts or damage caused by climate hazards Existing poplars trees by the route in Coton Orchard will be pollarded to reduce the risk of trees falling onto the road and maintaining safety for road users. A Landscape management plan will be provided to ensure vegetation is appropriately managed to reduce risks of damage and impact on end users.	▪ Landscape management plan; and ▪ Operational maintenance and monitoring arrangements.

5 ASSESSMENT OF IMPACTS AND EVALUATION OF EFFECTS

5.1.1. The assessment of significance of effects has been undertaken by considering the likelihood and the consequence of the potential impacts of climate change occurring as outlined in **Section 3.** The assessment of effects takes into account mitigation embedded in the C2C Scheme's design as detailed in **Section 4**. **Table TR3-5-1** provides the assessment of significance of effects for the C2C Scheme.

Table TR3-5-1 - Assessment of significance of effects for the C2C Scheme

Climate Hazard	Receptor affected	Potential Impacts and effects	Likelihood	Consequence	Significance
Precipitation ▪ Changes in annual average; and ▪ Extreme precipitation events.	**Scheme Assets:** ▪ New and existing busway including junctions; ▪ Shared use path; ▪ Structures (bridges, under/overpasses); ▪ Travel hub (parking areas and building); and ▪ Drainage features (culverts, detention ponds / SuDS etc).	Flooding resulting in damage to roads and structures.	Medium	Minor adverse	Not Significant
	Scheme Assets ▪ New and existing busway including junctions; ▪ Shared use path; ▪ Structures (bridges, under/overpasses); ▪ Travel hub (parking areas and building); and ▪ Drainage features (culverts, detention ponds / SuDS etc).	Overwhelmed drainage leading to surface water flooding.	Medium	Minor adverse	Not Significant
	Scheme Assets ▪ Embankments.	Subsidence resulting in damage to roads and structures (from drought or increased precipitation / flooding).	Medium	Minor adverse	Not Significant

Climate Hazard	Receptor affected	Potential Impacts and effects	Likelihood	Consequence	Significance
	Scheme Assets ■ Traffic control / signage / other electrical.	Damage to electrical equipment from water ingress resulting in failure of equipment.	Low	Minor adverse	Not Significant
	Scheme Assets ■ Landscaping / habitat creation.	Damage to / loss of vegetation (from flooding or from drought conditions).	Medium	Minor adverse	Not Significant
		Longer growing season, more vigorous vegetation growth in spring and autumn resulting in increased maintenance.	Very High	Negligible	Not Significant
	End Users of the Scheme	Safety risks and disruption to end users from flooding or aquaplaning.	Medium	Minor adverse	Not Significant
		Potential for emergency access vehicle to have access issues to the development from localised flooding.	Medium	Minor adverse	Not Significant
Temperature ■ Change in annual average temperature ■ Extreme temperature events	**Scheme Assets** ■ New and existing busway including junctions; ■ Shared use path; ■ Structures (bridges, under/overpasses); and ■ Travel hub (parking areas and building).	Deformation and/or melting of surfaces resulting in damage and increased maintenance.	Medium	Minor adverse	Not Significant

Climate Hazard	Receptor affected	Potential Impacts and effects	Likelihood	Consequence	Significance
	Scheme Assets ▪ New and existing busway including junctions; ▪ Shared use path; ▪ Structures (bridges, under/overpasses); and ▪ Travel hub (parking areas and building).	Increase in thermal expansion of structure joints compromising structural integrity leading to increased maintenance.	High	Minor adverse	Not Significant
	Scheme Assets ▪ Embankments; and ▪ Structures (bridges, under/overpasses).	Shrinking and cracking of soils resulting in damage to infrastructure and increased maintenance.	Medium	Minor adverse	Not Significant
	Scheme Assets ▪ Traffic control / signage / other electrical infrastructure.	Faster rate of deterioration of materials from increase in UV radiation (for example, brittleness and fading) causing damage and requiring early replacement.	Medium	Minor adverse	Not Significant
	Scheme Assets ▪ Traffic control / signage / other electrical infrastructure.	Risk of fire resulting in power outage, disruption and increased maintenance.	Low	Minor adverse	Not Significant
	Scheme Assets	Loss of vegetation cover due to scorching leading to destabilisation.	Medium	Minor adverse	Not Significant

Climate Hazard	Receptor affected	Potential Impacts and effects	Likelihood	Consequence	Significance
	▪ Landscaping / habitat creation.	Longer growing season, more vigorous vegetation growth in spring and autumn requiring increased maintenance.	Very High	Negligible	Not Significant
	End users of the Scheme	Stopping of services due to asset failure.	Medium	Minor adverse	Not Significant
		Overheating of electronic equipment and fire resulting in disruption to services.	Medium	Minor adverse	Not Significant
		End users at risk from overheating, particularly in a heatwave.	Medium	Minor adverse	Not Significant
Wind ▪ Gales and extreme wind events; ▪ Storms	**Scheme Assets** ▪ Structures (bridges, under/overpasses).	Increase wind loading on structures.	Medium	Minor adverse	Not Significant
	Scheme Assets ▪ New and existing busway including junctions; ▪ Shared use path; ▪ Structures (bridges, under/overpasses); ▪ Travel hub (parking areas and building); and ▪ Drainage features (culverts, detention ponds / SuDS etc).	Windborne dust and debris causing clogging drainage and requiring clearing.	Medium	Negligible	Not Significant

Climate Hazard	Receptor affected	Potential Impacts and effects	Likelihood	Consequence	Significance
	Scheme Assets ▪ Traffic control / signage / other electrical infrastructure.	Damage from high winds and rain infiltration into components resulting in power outages.	Medium	Minor adverse	Not Significant
	Scheme Assets ▪ Traffic control / signage / other electrical infrastructure.	Lightning strikes causing fires.	Medium	Minor adverse	Not Significant
	Scheme Assets ▪ Landscaping / habitat creation.	Vegetation damage / uprooting of trees.	Medium	Minor adverse	Not Significant
	End users of the scheme	Power loss resulting in disruption to services.	Medium	Minor adverse	Not Significant
		Trees blown down and increase in debris causing safety risks or distribution to services.	Medium	Minor adverse	Not Significant
		Uncomfortable and/or unsafe wind speeds resulting in safety risks.	Medium	Minor adverse	Not Significant

5.2 IN-COMBINATION CLIMATE IMPACTS

5.2.1. Potential ICCI with the environmental topics assessed within this EIA have been outlined in **Table 3-5-2**, identified from consultation with all topic specialists.

Table TR3-5-2 - Potential Impacts of Climate Change

EIA topic	Climate hazard	Potential impact of climate change	Mitigation
Ecology	Various	There is strong evidence that climate change is affecting UK biodiversity. Habitat types are likely to change in composition, as distributions of many species shift northwards. The risk of failure of mitigation planting and wetland areas is increased by more extreme and frequent drought. Although there may be some changes in species populations and distribution in the longer term, the majority of species and habitats included within the assessment are likely to remain stable in the short term (one to two years) until construction of the Scheme. It is therefore considered unlikely that the ecological baseline will change significantly prior to construction. There may be some changes to species populations and distribution in the longer term and throughout the operation of the Scheme. However, it is considered unlikely, given the mitigation and compensation delivered by the Scheme with regards to biodiversity, that predicted effects will be significantly exacerbated or ameliorated through climate change.	Planning condition to ensure an obligation on scheme owners to maintain landscape planting in a healthy condition.
Major accidents and disasters	Various	Assumed as part of general assessment as a potential cause of major accidents and disasters	None.
Archaeology	Decreased summer precipitation; increased summer temperatures	Differential settlement of ground caused by decreases in moisture content could, in extreme circumstances, be sufficient to damage archaeological remains (e.g. drying out of organic remains within normally anaerobic environments). Note that the Proposed Scheme has a likely low potential for preserved alluvial remains (see Technical Report 7 - Heritage Impact Assessment Section 5.2).	It is not possible to accurately quantify the effect of climate change on potential below ground archaeological remains and would therefore only be relevant in very extreme

EIA topic	Climate hazard	Potential impact of climate change	Mitigation
			cases (i.e wetland/floodplain environments). Therefore, the potential impact across the C2C Scheme is considered immaterial and no mitigation is recommended or relevant.
Geology and soils	Increased summer temperatures	Differential settlement of ground caused by decreases in moisture content can be sufficient to damage property, roads, and infrastructure.	Geotechnical testing to ascertain any pre construction ground improvement requirements.
	An increase in winter precipitation and a decrease in summer precipitation	Potential future increases or decreases in precipitation could affect groundwater (and consequentially surface water) quality underlying the C2C Scheme as potential contaminants currently above the groundwater table could be mobilised.	Long term monitoring of the groundwater table to assess seasonal fluctuations in groundwater levels.
Landscape and Visual	Increased occurrence of high summer temperatures humidity and heatwaves	Potential increase in failed mitigation planting due to heatwaves and drought.	Planning condition to ensure an obligation on scheme owners to maintain landscape planting in a healthy condition.
Acoustics	N/a	None	None
Air quality	Various	The assessment used best available data to model likely future conditions, both without and	None. Measures set out in the

EIA topic	Climate hazard	Potential impact of climate change	Mitigation
		with the Scheme. There is uncertainty regarding future meteorological conditions and subsequent dispersion of the pollutant concentrations. There is also potential for increased dust soiling and higher particulate matter (PM10 and PM2.5) concentrations due to likely hotter climatic conditions which could affect soil stability and surface run off.	CoCP will be sufficient to address risks from increased pollution of air.
Water	Increased peak rainfall intensity and increased peak river flows	The most likely change would be associated with an increase in peak river flows and peak rainfall intensity. The C2C Scheme is mainly located within the Cam and Ely Ouse Catchment. In this region it is predicted that by 2115 peak river flows could increase by 19%, the higher central allowance which is used for essential infrastructure schemes such as the C2C Scheme. This may increase the frequency of flood risk to identified receptors and increase the extent of Flood Zones 2 and 3, resulting in a greater area of the C2C Scheme being at risk of fluvial flooding. The peak rainfall intensity may also increase as a result of climate change, which could potentially increase the risk of surface water flooding to the C2C Scheme. The Environment Agency provides guidance on the central and upper end allowances on a catchment basis. The total potential change anticipated is a 35% increase in the 3.33% AEP rainfall event and a 40% increase in the 1% AEP rainfall events.	The Bin Brook crossing has been designed to accommodate the 1% AEP event with a 19% climate change allowance. The smaller watercourse crossings have been designed to ensure that the 0.1% AEP flows can be conveyed. The surface water drainage strategy has been designed to accommodate the 3.33% AEP design flows.
Community and human health	N/a	None	None
GHG	N/a	None	None
Materials and waste	Extreme weather event (e.g. intense downpour / winds)	Damage to stockpiles of material assets and construction waste.	Implementation of stockpile protection measures as set out through the Code of Construction Practice.

PREDICATED CUMULATIVE EFFECTS

Intra-project Combined Effects

5.2.2. The Climate Resilience assessment looks at the potential impacts of environmental change on the C2C Scheme, rather than impacts of the C2C Scheme on the environment: the receptor for the Climate Resilience assessment is the C2C Scheme. As such, no assessment of intra-project combined effects is undertaken, as there are no receptors in common with other assessments.

Inter-project Cumulative Effects

5.2.3. No inter-project cumulative effects are anticipated on the basis that the adaptation effects and impacts are specific to the C2C Scheme and will not result in any additional impacts to neighbouring developments.

6 SUMMARY OF LIKELY SIGNIFICANT EFFECTS

6.1.1. The assessment of vulnerability of the C2C Scheme to climate change during the operation phase has identified no likely significant effects.

6.1.2. Incorporating the embedded mitigation within the design and operation of the C2C Scheme, the potential effect of future climate conditions associated with precipitation, temperature and wind are considered to be not significant.

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